HUDSON RIVER
ENVIRONMENTAL SOCIETY

2019 Hudson River Symposium

Ecosystem Response to Climate Change and Sea-level Rise

Wednesday May 8, 2019
College Center, Villard Room
Vassar College
9:00 AM - 5:30 PM

Climate change and sea-level rise presents significant challenges for natural resource resiliency and management of the Hudson River estuarine ecosystem. Oceanic changes can alter the timing and magnitude of fish migrations. Changing sediment dynamics in the river have altered aquatic habitats and could lead to shifts in fish and wildlife communities. Sea level rise and frequency of major storm events may alter tidal wetland function and distribution.

This symposium will present current research and management options. The day will conclude with a contributed poster reception presenting a vast array of research and monitoring programs and results in the Hudson River Watershed.

Symposium Sponsors and Collaborators:

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Thank you!

The Hudson River Environmental Society wishes to thank the following people for their invaluable help in developing today's agenda: Sarah Fernald, Nordica Holochuck, Gregg Kenney, Dennis Suszkowski, and David Yozzo.

We also thank today's speakers and poster presenters for their commitment to present their latest work and knowledge on the complex interactions of humans and the Hudson River environment.

HRES is very grateful for today's sponsors whose generosity allows us to keep the costs down for all of the conference participants:

The Hudson River Foundation

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We are also very grateful to our Grady Moore Student Fund raffle contributors.

We wish to thank our individual members for your continued financial support of our efforts to bring contemporary scientific and environmental issues and information to the Hudson Valley.

Finally, HRES would like to acknowledge the 2018 HRES Board of Directors:

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HUDSON RIVER
ENVIRONMENTAL SOCIETY

2019 Hudson River Symposium: Ecosystem Response to Climate Change and Sea-Level Rise in the Hudson Estuary

Vassar College - College Center - Villard Room
Wednesday May 8, 2019-8 am to 5:30 pm
Registration: 8 am. - Talks start at 9 a.m. - Poster session: 4 pm

8:00 Registration

9:00 Introduction – *Lucy Johnson, President, Hudson River Environmental Society*

9:15 Climate Change Session

- Introduction – *Emilie Hauser, Hudson River NERR*
- Assessing the Risk: Climate risk in the Hudson Valley - *Daniel Bader, Program Manager, Consortium for Climate Risk in the Urban Northeast at Columbia University Earth Institute*
- Adapting to New York's wetter climate - *Mark Lowery, Assistant Director Office of Climate Change NYSDEC*

10:35 Break

11:00 Fisheries Session

- Introduction - *David Yozzo, HDR, Inc.*
- Processes underlying climate driven shifts in mid-Atlantic Bight fish: Distributions inferred from sustained collaborative research within two winter fisheries- *John P. Manderson, NOAA/NEFSC Oceans & Climate and Cooperative Research Branches*
- Adaptation to climate change: Can we better equip Hudson River fishes to succeed? - *David H. Secor, Professor, Chesapeake Biological Laboratory University of Maryland*
- Historical and projected changes in spawning phenologies of American shad and striped bass in the Hudson River Estuary - *Christopher C. Nack, SUNY ESF and O'Brien and Gere, a part of Ramboll*

12:50 Lunch

HUDSON RIVER
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1:50 Tidal Wetlands

- Introduction – *Stuart Findlay, Cary Institute of Ecosystem Studies*
- Monitoring Hudson River tidal wetlands for climate change resilience - *Sarah Fernald, Hudson River National Estuarine Research Reserve*
- Conserving Hudson River tidal wetlands in an age of sea-level rise - *Nava Tabak, Director of Science, Climate, & Stewardship, Scenic Hudson, Inc.*
- Rapid tidal marsh development on the Hudson during period of tributary damming and shoreline modification- *Brian Yellen and Jon Woodruff UMASS, Dept. of Geosciences*
- Using dredged material to enhance New Jersey salt marshes - *Joel A. Pecchioli, Research Scientist, Environmental Toxicology and Risk Assessment New Jersey Dept. of Environmental Protection (remote attendance)*

3:40 Concluding Remarks: *Karin Limburg SUNY ESF*

4:00 – 5:30 ***Poster Session, Reception and Student Travel fund Raffle***

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SPEAKER ABSTRACTS

Assessing the Risk: Climate Risk in the Hudson Valley

Daniel Bader
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Program Manager, Consortium for Climate Risk in the Urban Northeast
Columbia University Earth Institute

The Hudson Valley has long been vulnerable to weather and climate risks, many of which are projected to increase in the future. Recent extreme weather events have exposed many of these vulnerabilities and reinforced the need for New York State to continue responding to the challenges presented by a changing climate. An overview of the key local climate hazards and observed climate trends in the Hudson valley will be presented. Next, state of the science climate projections for this region (developed specifically for decision-making) will be discussed. The presentation will conclude with a summary of how these climate projections are informing policy at the local and state level.

Adapting to New York's wetter climate

Mark Lowery
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Assistant Director, Office of Climate Change
New York State Department of Environmental Conservation

:

Although New York State faces a variety of climate-change hazards, flooding associated with extreme-precipitation events and sea-level rise has been the focus of most state government policies. This presentation will review the provisions of the 2014 Community Risk and Resiliency Act and challenges associated with implementation of this law. A review of other climate adaptation and resilience programs, including Climate Smart NY, Resilient NY, SEQR regulation amendments and Climate Smart Communities will be included.

Processes underlying climate driven shifts in mid Atlantic Bight fish distributions inferred from sustained collaborative research within 2 winter fisheries.

John P Manderson,
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NOAA/NEFSC Oceans and Climate and Cooperative Research Branches

The phenomenological consequences of climate change on fish distributions and productivity have been documented largely on the basis of macro-ecological analyses of coarse scale fishery independent surveys (survey grains: bi-annual, 24 km^{-2}. Extents. 30+ yrs, ~200,000 km^{-2}). Understanding present and predicting future population and ecosystem states that are likely to be novel due to impacts of rapidly changing climate requires empirical understanding of the coupled atmosphere-ocean-ecological processes that operate at fine space-time scales (Grains: Days, 10 - 1000s km^{-2}. Extents: Weeks to seasons; 1000s km^{-2}) but that have broad sale ecosystem impacts. Traditional science programs are too expensive to be sustained at the broad range scales required to elucidate ecosystem processes underlying phenomenological trends. I present examples from a program that uses collaboration and crowdsourcing within active mid Atlantic Bight winter fisheries to develop applied empirical science products accounting for changing ecological and human dimensions in ecosystem assessments. Real time fisheries field science and monitoring suggest that the timing and extent of seasonal fish migrations affecting fisheries as well as fishery independent observations are fundamentally controlled by the impacts of coastal storms on air-sea interactions and on the changing dynamics of more remote forces such as the gulfstream. These processes appear to be impacting locations and timings of suitable habitats and thus fish distributions and productivities. Failure to accurately and explicitly account for impacts of atmosphere-ocean-ecological processes on fish populations, fisheries, and the scientific observations that inform assessments is putting severe stress on human dimensions of the regional fisheries ecosystem.

Adaptation to climate change: Can we better equip Hudson River fishes to succeed?

David H. Secor
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Chesapeake Biological Laboratory, University of Maryland Center for Environmental Science

The Hudson River Estuary maps past and ongoing human influences – navigation and ecological corridors, centuries of fishing, industrial and urban degradation and clean-up, generations of invasive species and climate change. During the past four decades, there are strong emerging trends of climate forcing observed as changes in temperature, flow, food web structure, ecosystem phenology, and summer storm frequency. Yet the Hudson River Estuary harbors one of the healthiest assemblages of diadromous species among US Atlantic estuaries. What permits these populations to succeed and how can we promote their future resilience to climate change? Reviewing Hudson River Foundation-supported research, I show how Hudson River white perch and striped bass are equipped to succeed through their ability to adapt life history and migration behaviors to changing ecosystem conditions. Insuring that this “bag of tricks” can continue to be exercised by Hudson River fishes directs conservation priority on maintenance of diverse habitats and conservation of population structure in fisheries management.

Historical and future changes in spawning phenologies of American Shad and Striped Bass in the Hudson River Estuary

Christopher C. Nack
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O'Brien & Gere Engineers, Inc
Department of Environmental and Forest Biology, SUNY College of Environmental Science and Forestry

Dennis P. Swaney
Department of Ecology and Evolutionary Biology, Cornell University

Karin E. Limburg
Department of Ecology and Evolutionary Biology, Cornell University

Predicted increases in temperature over the next century have raised many concerns about changes in life history traits and geological distributions of anadromous fishes. Anadromous fishes are particularly vulnerable to human activities due to the diverse array of habitats needed to complete their life cycle and the proximity of essential habitats to large human population centers. To understand the potential changes in spawning phenology of American Shad and Striped Bass in the Hudson River Estuary, a model was developed to project the onset, cessation and duration of the spawning season through the 21st century, using projected water temperatures. Water temperatures for the Hudson River estuary were determined using recent models accepted by the International Panel of Climate Change. Model results indicate that by the 2090s, the spawning season of both species will initiate, on average, approximately 15 days earlier in the year, with spawning duration reduced by four days compared to the average spawning season in the 2010s.

Monitoring Hudson River Tidal Wetlands for Climate Change Resilience

Sarah H. Fernald
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Research Coordinator, NEIWPCC/Hudson River National Estuarine Research Reserve
NYSDEC Division of Marine Resources

Tidal marshes are a significant habitat in the Hudson River Estuary, and are threatened by climate change stressors such as sea level rise. The Hudson River National Estuarine Research Reserve (HRNERR) installed a NOAA tide station in 2017 at Turkey Point, establishing an upper estuary tide station that, along with tide data collected at the Battery, can monitor actual increases in water level over time. To compare water levels to changes in the elevation of sediments within tidal marshes, Surface Elevation Tables (SETs) were installed in Tivoli Bay in 2012, and at Iona Island in 2014. SET stations provide a nondestructive method for making highly accurate measurements of sediment elevation over long periods of time relative to a fixed elevation benchmark. Tivoli Bay SETs were installed at a reference site, a site of potential marsh migration, and a site impacted by invasive *Trapa natans*. Iona Island SETs were installed at a site cleared of *Phragmites australis* in 2014, and a site where *Phragmites* has not yet been treated. Three SETs were installed in each

study segment. SET data were collected every spring, summer and fall since installation. Iona Island data have shown a lower rate of sediment accretion in areas where *Phragmites* was removed (6.3 mm/year) compared to areas of untreated *Phragmites* (13.5 mm/year). In Tivoli Bay, data from SETs adjacent to *Trapa natans* showed the highest accretion rates of 12.9 mm/year, followed by the reference site closest to the Hudson River main stem at 10.9 mm/year. The SETs closest to the shore had the lowest accretion rates at 5.0 mm/year. Loss on ignition (LOI) was used to measure the percent organic matter (%OM) in the sediment adjacent to the SETs in Tivoli Bay. Sediments closest to the Hudson River main stem had higher %OM (34.6%) that the other two sites (14.4%; 11.2%). A Marsh Resilience to Sea-level Rise (MARS) index was calculated and showed that, compared to other National Estuarine Research Reserves, Tivoli Bays is moderate to highly resilient to rising waters.

Presentation title: **Conserving Hudson River Tidal Wetlands in an Age of Sea Level Rise**

Nava Tabak
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We projected responses over the coming century for the nearly 7,000 acres of freshwater and brackish tidal wetlands along the Hudson River Estuary (HRE) using the Sea Level Affecting Marshes Model (SLAMM). While SLAMM has been widely used in the assessment of saline and brackish coastal wetlands, we adapted the model to reflect the unique freshwater tidal conditions of the HRE, as well as the specific local SLR projections and data availability for this system. By varying rates of SLR and wetland sediment accretion, we examined a range of possible future scenarios of wetland change and persistence. Results showed considerable potential for these wetlands to adapt, particularly through horizontal movement into adjacent undeveloped areas, but some existing wetlands may also experience dramatic losses or shifts in wetland composition over time. Rate of SLR was the strongest driver of model projections, while rate of accretion had the greatest impact in simulations with high SLR. We used the results of this study to identify priority sites for conserving wetland migration pathways, targeting currently undeveloped and unprotected uplands that are likely to host future tidal wetlands as well as existing wetland complexes exhibiting high resilience under a range of possible future conditions. Our findings also inform restoration and policy efforts that will increase tidal wetland resilience and conservation in the coming century.

Rapid tidal marsh development on the Hudson during period of tributary damming and shoreline modification

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John Woodruff
University of Massachusetts, Department of Geosciences

Thousands of legacy dams impound streams within the Hudson River watershed. These dams are being removed at an increasing pace to improve aquatic connectivity and public safety, yet the impacts of remobilizing impounded sediments behind these dams on downstream tidal environments remain unclear. Here we present results from surveys of sediments behind small impoundments in three tributary catchments along the Hudson River estuary. We pair results from tributary impoundments with observations of tidal marsh sediments at the mouth of each of the catchments. To generalize the potential impacts of dam removals on sediment dynamics in the estuary, we classify three types of dams: (1) active sediment traps with accommodation space at present; (2) run-of-river dams that contain sediment, but are presently filled; (3) impounded natural lakes where dam removal would not increase downstream sediment transport.

In some tidal marshes, we find that anthropogenic alterations to the estuarine bathymetry or shoreline (e.g. railroad trestles, dredge spoils emplacement) have dramatically increased deposition of fine-grained marsh muds. Marshes have vertically accreted at 1-2 cm/yr, much faster than relative sea level rise, despite the onset of these marshes during the period of peak dam building and potential reduction in sediment supply. This suggests that marsh-building sediment originates predominantly from the main stem of the river, not local tributaries, and that this supply is sufficient to maintain accretion rates much greater than sea level rise. Any increase in sediment supply due to dam removal on these tributaries would have little impact on tidal wetlands along the main channel of the Hudson.

Presentation Title: Using Dredged Material to Enhance New Jersey Salt Marshes

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Metthea Yepsen
New Jersey Department of Environmental Protection

In 2013, the New Jersey Department of Environmental Protection and multiple partners initiated three pilot projects to evaluate the concept that the beneficial use of dredged material on existing, but stressed and vulnerable, salt marshes would improve their structure, ecological functions, and resiliency. This presentation will provide an overview of the three projects and how they were developed, designed, constructed, and monitored. The Ring Island (Cape May County) thin-layer placement pilot project included placing dredged material that was 96% fine sand onto two 0.5-acre areas and the creation of a 1-acre elevated nesting habitat for colonial shorebirds. The Avalon (Cape May County) project was implemented in two phases (total 45 acres) with the objective to fill degraded and expanding pools with predominantly fine-grained (72% silt/clay) dredged material; the overflow from the pools would result in thin-layer placement of the dredged material on the surrounding marsh plain. Given the heterogenous grain size of the sediment to be dredged, the Fortescue (Cumberland County) project had three components: marsh enhancement (6.6 acres), dune restoration (2.25 acres), and beach nourishment (1.6 acres). The Project Team carefully documented what was done and developed an extensive list of “lessons learned” during project design, construction, and post-construction marsh recovery. The importance of coordinating each marsh enhancement project with its associated dredging project will be emphasized.

POSTER ABSTRACTS

Preferential transport of high salinity groundwater via geologic fault structures connecting highways to creeks

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Salinity levels in many streams in the Hudson River watershed have increased, correlating with the surge in use of NaCl as a deicing agent on roads. These rises in salt concentrations have led to decreases in water quality and have impaired the ecological health of the system. Instead of seeing river salinity levels decline during summer months, when there is a negligible application of salt, levels of salinity are still increasing. This increase corresponds to the time period when groundwater input to stream surface flow is at its peak. We estimate a statistically significant correlation between rises in stream salinity and input locations of groundwater along geologic fault-zones. After visiting three different stream reaches of Wappingers Creek, in Dutchess County, NY, we determined there were cases of water becoming significantly saltier following a fault-zone crossing. Our findings suggest fault-zones can facilitate transport of high salinity groundwater from roadways into streams, even from kilometers away.

Do Constructed Wetlands Improve Stormwater Quality During the Winter? A Bard College Study

Damaris Borden, Julia Gloninger, Rory Kuczek, Mikaela Martiros, Patrick Toohey, Erica Walsh
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Constructed wetlands (CWs) are a form of stormwater management built to mimic the ecosystem services of natural wetlands. Our study focuses on the constructed wetland at Bard College, which was built to redirect and treat campus stormwater before it entered the Saw Kill River, a Hudson River tributary and the source of campus drinking water. CWs are an increasingly popular solution to issues of stormwater quantity and quality; however the effectiveness of these systems is rarely evaluated following implementation, which makes unclear the extent to which ecosystem service benefits are realized. Our research focuses on evaluating the effectiveness of the constructed wetland on the Bard College campus at treating stormwater specifically in the winter. During the winter, the constructed wetland vegetation is not growing and the system is inundated by large amounts of road salt. We conducted weekly samplings in addition to storm event sampling where we measured water depth in pipes, temperature, dissolved oxygen, conductivity and turbidity at several points along the constructed wetland. Our analysis of the data has shown that the constructed wetland seems to be ineffective during storm events, and only minimally effective on base flow days. We hypothesize that the relative ineffectiveness of the system is likely due to the lack of dredging or the small size of the constructed wetland relative to the volume of stormwater received.

Hale Creek Field Station

David Bryk
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Tanya Jasewicz, Nicholas Sanges, Chloe Armato, Brian Buanno, John Finn
NYS Dept. of Environmental Conservation, Bureau of Habitat, Division of Fish and Wildlife

The Hale Creek Field Station ("HCFS"), located in Gloversville New York, is operated by the New York State Department of Environmental Conservation. HCFS is the only New York State operated laboratory that analyzes fish and wildlife tissues from animals collected across all of New York for legacy contaminants (*e.g.,* PCBs, Organic Pesticides, and Mercury) and contaminants of emerging concern (*e.g.,* perfluoroalkyl substances, PFAS). The resulting data are used by New York State Department of Health to develop health advice on eating sportfish and game. These data are also used to determine ecological impacts of environmental contaminants and to track the recovery of organisms following a superfund clean-up. Essentially, all the work conducted at Hale Creek since the 1970s is dedicated to safeguarding the fish and wildlife resources of New York. In addition to analyzing fish and wildlife for contaminants, the HCFS contains stocked fish ponds and raceways as well as miles of hiking trails for the public to enjoy and hosts an annual environmental science day event for local 7th graders.

Tracking aerosolized sewage using community science tools

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Most passenger trains have Hopper toilets on board, which may release excretory waste onto train tracks while traveling. This waste would likely carry fecal bacteria like *Entero*, *E. Coli* and Coliforms, organisms capable of impacting human health. The momentum and velocity of trains may subsequently aerosolize this liquid waste, releasing particulate matter into the air. We hypothesize that trains *may* cause an increased level of fecal bacteria in the air, which may harm humans, based on our understanding of train plumbing. Since the Rhinecliff Station, and local train tracks, are parallel to the Hudson River, the waste released by the trains likely runs off into the Hudson River, and exist within the local air, influencing nearby organisms and habitats.
To test our hypothesis, we have constructed, calibrated, and deployed citizen science air sampling devices, coupled with a portable particulate matter sampler, to take grab samples of ambient air before, during, and after the passage of trains at the Rhinecliff Station in Rhinebeck, NY. Using the EPA-approved IDEXX Enterolert and Colilert assays, we are testing grab air samples for the presence of fecal indicating bacteria.

Reconnecting Our Streams: Barrier Mitigation in the Hudson River Estuary Watershed

Stephanie Facchine
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NYSDEC Hudson River Estuary Program and Student Conservation Association/Americorps

Megan Lung
NYSDEC Hudson River Estuary Program and New England Interstate Water Pollution Control Commission

Poorly designed road-stream crossings (e.g., culverts and bridges) as well as unused or failing dams (according to statewide dam safety inspections) may act as barriers to free flowing streams by disrupting the natural flow and function of waterways. Such barriers may restrict the movement of aquatic organisms and present hazards for communities by increasing flooding risks. In the Hudson River Estuary watershed alone, there are over 15,000 predicted crossings and 1,600 dams. As part of its Culvert Prioritization Project, the Hudson River Estuary Program of the New York State Department of Environmental Conservation (NYSDEC) has been working with interested partners to assess all road-stream crossings within the Hudson River Estuary Watershed and prioritize crossings most in need of replacement. Once priority crossings are identified, Estuary Program staff coordinate with interested municipalities and local organizations to facilitate crossing replacements. In addition to culvert prioritization, Estuary Program staff work on barrier mitigation projects that prioritize unused or failing dams with potential for removal. Site visits are an essential step in identifying priority dams and understanding the complex issues involved at each site. Case studies in the Hudson River Estuary Watershed provide insight into the problems dams may cause for waterways and the necessary considerations when discussing the future of each dam, including the benefits, costs, and obstacles involved in removal or inaction. In addition to the ultimate goal of removing barriers to organism movement and reducing flood hazards for communities, barrier mitigation projects offer unique opportunities for community outreach and involvement.

Research Funding Opportunities for College and Graduate Students at the Hudson River National Estuarine Research Reserve

Sarah Fernald
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Emilie Hauser
NYSDEC Hudson River National Estuarine Research Reserve and NEIWPCC

The Hudson River National Estuarine Research Reserve, with four research sites along 100 miles of the Hudson Estuary has several opportunities for funded research for undergraduate and graduate students. Three opportunities provided in partnership with for NOAA will be described: 1) The Hollings Undergraduate Scholarship Program; 2) NOAA College-Supported Internship Program and; 3) The new 2020 Margaret A. Davidson Fellowship for graduate students. In addition, the Tibor T. Polgar Fellowship in cooperation with the Hudson River Foundation provides funding for eight students to conduct research on the Hudson.

Sediment Accretion Rates and Organic Matter at Surface Elevation Table (SET) Stations in Tivoli Bay and Iona Island

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Christopher Mitchell
Hudson River National Estuarine Research Reserve

Gabriella Basso
SUNY New Paltz

To measure the relative elevation of sediments within the tidal marshes of the Hudson River Estuary, Surface Elevation Tables (SETs) were installed in Tivoli Bay in 2012, and at Iona Island in 2014. SET stations provide a nondestructive method for making highly accurate measurements of sediment elevation over long periods of time relative to a fixed elevation benchmark. Tivoli Bay was divided into three study segments including OTN, a reference site, ITN, a site of potential marsh migration, and TSB, a site impacted by invasive *Trapa natans*. Iona Island was divided into two study segments including IIE, a site cleared of *Phragmites australis* in 2014, and IIW, a site where *Phragmites* has not yet been treated. Three SETs were installed in each study segment. SET data were collected every spring, summer and fall since installation. Iona Island data have shown a lower rate of sediment accretion in areas where *Phragmites* was removed (6.3 mm/year) than areas of untreated *Phragmites* (13.5 mm/year). In Tivoli Bay, data from SETs adjacent to *Trapa natans* showed the highest accretion rates of 12.9 mm/year, followed by the reference site closest to the Hudson River main stem at 10.9 mm/year. The SETs closest to the shore had the lowest accretion rates at 5.0 mm/year. Loss on ignition (LOI) was used to measure the percent organic matter (%OM) in the sediment adjacent to the SETs in Tivoli Bay. Sediments closest to the Hudson River main stem had higher %OM (34.6%) that the other two sites (14.4%; 11.2%).

Hudson River PCBs Site – Evaluating Remedy Performance Using Fish Data

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John Armitage
New York State Department of Environmental Conservation

The primary remedy performance metric established by EPA in the 2002 Record of Decision (ROD) for the Hudson River PCBs Site is a Species and River Section Length Weighted Average Total PCB concentration in fish. The Remedial Action Objectives (RAOs) in the ROD included specific time frames to achieve quantitative target concentrations using this metric, 0.4 parts per million (ppm) five years after dredging, and 0.2 ppm sixteen years after dredging.

By comparing the post-dredging fish PCB concentrations to those anticipated by EPA, and to the targets established in the ROD, remedy performance can be assessed. The changes in fish PCB concentrations at individual stations can also be assessed to determine if the rates of decline are steady post dredging, or if they are slowing over time.

The available fish data do not support the conclusion that there is robust ongoing recovery in upper Hudson River fish PCB concentrations. Rather, the data support a conclusion that the existing concentrations remain well above the EPA RAOs, that the rate of decline is slowing, and that it is unlikely that the RAOs will be met by the existing remedy.

Hudson River PCBs Site – Temporal Trends in Upper Hudson Fish PCB Concentrations

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John Armitage
New York State Department of Environmental Conservation

GE gathers fish samples from fourteen locations in the upper Hudson River in the area where the dredging remedy was implemented. These fourteen locations have been monitored by GE starting in 2004, with annual collections before, during, and after the dredging work.

Temporal trends in fish PCB concentrations are evaluated by species and location using the wet weight total PCB concentrations in fish and the associated lipid content data to calculate a lipid normalized fish PCB concentration. Calculated lipid normalized data are plotted with time to evaluate the changes in PCB concentrations associated with the dredging remedy and with natural recovery processes.

The primary metric for evaluating the success of the remedy for the upper Hudson portion of the Hudson River PCB site is the ability of the remedy to meet specific targeted reductions in species weighted and river section length weighted average wet weight fish PCB concentrations.

In evaluating the temporal trends in this metric, it is useful to understand the temporal trends at each of the locations which make up this average. A good way to understand the temporal trends at each location is to lipid normalize, which accounts for variability caused by changes in lipid content from year to year. With few of these species/locations showing continuing robust declines in LPCB concentrations, it is unlikely that the primary metric used by EPA to evaluate performance of the remedy will also exhibit sufficient declines to meet the Remedial Action Objectives set the Record of Decision.

The Presence and Significance of Microplastics in the Lower Hudson River Estuarine Sanctuary, NYC

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Carrie Roble, Brett Branco, PhD, Marika Krupisky, Helen Polanco
Brooklyn College, Hudson River Estuary Lab

Microplastics are an emerging issue that has gained increased attention by the scientific community due to the global impact of plastics in the ocean. Since 2016, Hudson River Park has collaborated with Brooklyn College to conduct a survey that investigates the concentration and distribution of microplastics that are < 5mm in size, in Hudson River Park's estuarine sanctuary with in the area of Chambers Street to 59th Street in New York City. This ongoing monitoring project has developed a baseline understanding of the presence of microplastics in the Hudson Estuary. Hudson River Park's Estuary Lab conducts this survey by trawling a Neuston net at channel and near shore locations as well as counting and categorizing the debris types found in the sample through microscopic analysis. Statistical analyses revealed that microplastic concentrations in 2016, 2017, and 2018 are significantly different (ANOVA, $p<0.001$). Further data analysis suggests that the significant differences may be representative of varying wet weather conditions during the each year's sampling season. The comparison of microplastic concentration across all three years has given rise to new research questions related to weather fluctuations, collection methods, tidal influences, and the proximity to combined sewage out flow. Future surveys following the 2019 Styrofoam ban in New York City and other discharge reduction measures will assess the effectiveness of these measures.

Population Trends for Key Species of the Hudson River Estuary at Pier 25 from 2012 to 2018

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Justin Siddhartha, Walker Hayes
The River Project

For 30 years The River Project (TRP) has conducted a Fish Ecology Study at various sites within a 1 mile stretch of near-shore waters on the West side of Manhattan, New York City. The most recent site, Pier 25, has been closely monitored for the past seven years. This site is comprised of the permanently moored lighthouse tender ship, *Lilac*, with 20 minnow traps and 4 crab pots deployed around the circumference of the hull. The collection gear is checked year-round by TRP staff and interns at a minimum of once per week in the winter to 4-5 times per week in the summer. At this site, 1899 fishes of 31 species have been caught, measured, and either released or temporarily housed in TRP's Wetlab Aquarium for use in environmental education. This monitoring effort highlights the population flux of key species – species that are significant due to commercial or bioindicative importance, or are highly abundant – so as to provide robust population data for use by the scientific community as well as city and state agencies. Through the continued observance of the abundance, size, and incidence of Lower Hudson Estuary fishes, TRP seeks to further hone fish population data in order to facilitate the conservation of this highly diverse river system.

Identifying spatial and temporal drivers of waterborne pathogen dynamics of the Hudson River watershed

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Fecal contamination is a significant source of water quality impairment. The aim of this study is to apply machine learning approaches for identifying important predictors of pathogen concentration across flow conditions. I developed models to understand the fecal coliform and E. coli concentration responses to hydrologic variables across the entire New York river system. This study found that the storm runoff ratio index, derived from hydrographs, is a better predictor than precipitation and runoff to characterize hydrologic impact on pathogen concentrations. These results suggest that watershed hydrologic factors are critical to pathogen concentration forecasting. Moreover, the relationship between fecal contamination and environmental variables (e.g., temperature, runoff) derived from this study can be used to predict the fecal contamination under various climate change scenarios.

Newtown Creek Vascular Plant Survey: Using citizen science to understand urban biodiversity

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Elise Heffernan
Hudsonia Ltd

Lisa Bloodgood
Newtown Creek Alliance

Newtown Creek is a 3.8-mile long, heavily industrialized tributary of the East River. The Creek is an important, hidden and largely inaccessible, natural resource for residents of North Brooklyn and Western Queens. From October 2017-September 2018, the Newtown Creek Alliance (NCA) and Hudsonia Ltd. conducted a survey of all vascular plants within 100 meters of the shore in order to document present species and their relative abundances. Using the app, iNaturalist, we documented locations of species and rated abundances (dominant - rare) with the help of citizen scientist volunteers; we also collected specimens of species that are difficult to identify in the field, as well as representative samples, to curate an herbarium with NCA. Our iNaturalist project yielded 4461 observations from 41 volunteers; We identified 243* species (some species identifications are still in process) using the iNaturalist app and our own collection materials. Using inverse distance weighting interpolation in ArcMap, we generated a map of native and non-native species (weighted by relative abundance measures) along the Creek to identify hotspots of native communities and invasive species. This data will provide a list of species that thrive under the challenging conditions around the Creek and areas that could be prioritized for restoration. Of special interest is the need to develop adaptive strategies for waterways that will allow for the continuation of industrial uses while providing space for healthy ecosystems as sea levels rise. This baseline understanding of the current status of plant biodiversity and distribution is essential for future planning.

Landscape genetics of a tidal marsh perennial threatened by sea-level rise

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Climate change is resulting in large-scale habitat loss in many regions. This habitat loss is of particular concern in Mid-Atlantic marshes undergoing "coastal squeeze" due to accelerated sea-level rise. Competitive interactions between foundation plant species are resulting in the loss of high marsh habitat at the fastest rate, with projected losses of 90-100% in some areas. I propose an investigation of the relationship between habitat area and genetic diversity in *Spartina patens*, a clonal perennial which dominates the high marsh. I aim to determine the relationship between *S. patens* clonal diversity and both present and historical habitat area. I will genotype samples in patches of different sizes classes, from New York marshes with different current and historical high marsh area (as quantified by delineated spatial imagery). I will then assess to what degree genetic diversity is impacted by area at both the patch and landscape scale. This work has great significance for marsh conservation, as it will serve as an assessment of how much genetic variation, the fodder of natural selection, is being lost to climate change in a foundation species critical to maintaining the ecosystem services of coastal marshes.

Rates of Tidal Marsh Accretion: from Stockport Marsh to Iona Island

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To improve the Hudson River estuary's resilience to sea level rise, there are plans to create and restore tidal marshes along the river. While there is evidence that humans have had negative impacts to marshes, there is an increasing awareness that some modifications have actually created healthy tidal marshes along the tidal extent of the Hudson River. Here we present results from three inadvertent successful examples of marsh creation due to the emplacement of dredge spoils and the construction of piers and the railroad since the industrial era: Stockport Marsh, Tivoli Bays: North and South, and Esopus Marsh. For comparison, we present results from the natural marsh behind Iona Island (Rockland County, NY), that has remained healthy through the industrial era despite anthropogenic impacts to the surrounding landscape. Results show that anthropogenic alteration of the flow conditions at these locations created low-energy areas with high sediment trapping efficiency. This allowed for the fast accumulation of sediment and the development of robust freshwater tidal marsh systems that have accreted well in excess of estimates of future sea level rise. These rapidly formed marshes can serve as models to guide future marsh restoration efforts in the Hudson River estuary.

Exploring the effects of wood smoke on Hudson Valley air quality, public health, and climate

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The effects of wood smoke, and the particulate matter (pm) produced by it, can be detrimental to both the environment and to human health by degrading air quality. Wood smoke pollution can easily deposit into river bodies and affect ecological and drinking water systems (like those in the Hudson River), or be suspended as black carbon, absorbing high levels of solar radiation and impacting the climate. Studies have shown that individuals exposed to wood smoke become increasingly prone to negative health effects including: cancer, asthma, heart disease, diabetes, nervous system/cognitive impairment, premature heart attacks, and birth defects. Despite this well-documented impact on human health and climate, burning wood for fuel and for ambience is increasing in the Hudson Valley. To increase awareness and to more closely study human exposure to unsafe levels of pm at campfires and in fireplaces, we have built, tested and deployed community-accessible air sampling devices, supplemented and ground-truthed by data from a MetOne particulate counter. We hypothesized that grab samples collected in close proximity to wood burning fires would clearly demonstrate higher levels of pm2.5 and pm10 than grab samples from areas without wood-burning fires. Our sampling campaign is still underway, but we have verified the utility of our community air sampling devices in detecting pm levels exceeding EPA standards, suggesting that these devices might be a powerful public education and community research tool.

What Eels Teach Us About People: evaluating a citizen science project

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The Hudson River Eel Project aims to strengthen the connection between Hudson Valley residents and the river's ecosystem through engagement in citizen science. Thirteen nets are placed from New York City to Troy and volunteers check them daily each spring for juvenile glass eels. Eels are an ideal study species for a citizen science project because they are hearty, easy to handle, and are found in a diversity of habitats. This citizen science eel monitoring project is in its 11^{th} year and engages about 700 community volunteers annually. We recruit participants using a variety of methods including school assemblies, in-class programs, and public presentations. Self-reflective post-program evaluations ask participants to rank their knowledge and interest in their local stream environment. We see an increase in both metrics from a majority of participants. Through these evaluations we can also determine volunteer retention rate and gather important feedback from participants of the project. One high school student responded on an evaluation, "I enjoyed the ability to experience what actual conservation studies are like and the feeling of joy I got from participating in a volunteer study."

Freshwater Mussels as Biomonitors of Recovery following a Superfund Cleanup of a Large River

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Native freshwater mussels (Family: Unionidae) are stationary organisms that filter particles from the water, are long-lived, and can be aged by counting external growth annuli, making them potential biomonitors of local contamination and ecosystem recovery. We analyzed PCB concentrations in tissues from mussels that were collected in 2013 and 2015 from the upper Hudson River, including samples from one pool upstream of the PCB contamination sources. Three composite samples, each comprised of the tissues from five mussels, 75-80 mm in length, collected from unremediated areas within each pool were analyzed. As an indication of baseline PCB concentrations present prior to remedial activities, we extracted data from New York State's fish contaminant database for unionid mussels in the same size range that were collected by GE in 2007, prior to the start of remedial activities in 2009. PCB concentrations were lower in mussels collected in 2015 from Thompson Island and Northumberland Pools, but higher in Stillwater Pool. The higher concentrations in mussels from Stillwater may be in response to remedial activities in the pool immediately upstream concurrent with our mussel collections, leading to a spike in assimilated PCBs, i.e., a short-term response to the dredging. We plan to continue to collect mussels of the same size class (75-80 mm) on a 3-year cycle for PCB analysis to monitor long-term trends in PCB levels in mussels post-remediation as an indicator of environmental recovery.

Catalyzing a Deeper Understanding of the Effects of Storm Surge Barriers on the Hudson River Estuary

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The U.S. Army Corps of Engineers, states of New York and New Jersey, and New York City are partnering under the Harbor and Tributaries Focus Area Feasibility Study (HATS) to evaluate gated storm surge barriers and other options to manage coastal storm risks. The decision of whether or not to build surge barriers to protect one of our nation's main commercial hubs and ports, crossing one of our most iconic estuaries, is a major decision worthy of collaboration. The National Estuarine Research Reserve Science Collaborative funded a "Catalyst" project for one year with the following goals: (1) to facilitate development of a collaborative research agenda that can help interested parties better understand potential barrier effects on nearby estuaries, and (2) to undertake targeted research in close collaboration and with information-sharing among scientists and key end-users such as the Corps and its partners. The project team will conduct modeling and analyses of the physical influences of surge barriers and host a series of workshops to synthesize and share information. Outputs of the project will include several workshop reports, collaboratively-determined project plans and future work plans, scientific analyses of estuary physical processes, and written plans for expanding the research and the scientific community involved. Additional goals with this poster presentation are to seek input on topics of interest or concern, relating to surge barriers, and to share information on our plans for research and workshops to be performed this spring and summer.

How Do Pharmaceuticals Impact Denitrification in Water Chestnut (*Trapa)* Beds

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Pharmaceuticals are ubiquitous in the Hudson River as well as in freshwater rivers world-wide. Pharmaceuticals are biologically active and have the potential to act on non-target organisms, including microbes that provide important ecosystem services, at sub-lethal concentrations. The floating macrophyte *Trapa natans* densely vegetates shallow backwaters along the Hudson River's edge. Despite their invasive status, *Trapa* beds are integral to the Hudson River's ecology due to their substantial capacity for denitrification. This microbially-mediated nitrate removal process is vital for preventing eutrophication and harmful algal blooms. This study examines how the commonly used pharmaceuticals metformin (antidiabetic), ranitidine (histamine-2 blocker) and ciprofloxacin (antibiotic) affect denitrifying microbial communities within *Trapa* beds. Pharmaceutical diffusing substrates (PhaDS) were used to promote biofilm growth in the presence of pharmaceuticals. Denitrification and respiration rates were measured as dinitrogen production and oxygen consumption respectively using Membrane Inlet Mass Spectrometry, and microbial community structure was assessed with 16S profiling and whole genome metagenomics.

Hudson River Hydrilla and Aquatic Plant Survey

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The New York Department of Environmental Conservation (NYDEC) Bureau of Invasive Species and Ecosystem Health, Invasive Species Coordination Section in conjunction with Northeast Aquatic Research (NEAR) conducted an aquatic plant survey of a series of sites along the Hudson River from Newburgh to Troy. A highly invasive aquatic plant species *Hydrilla verticillata* is known to inhabit the Croton River, a tributary of the Hudson River. For that reason the NYDEC felt it was critical to investigate whether *Hydrilla verticillata* has spread to areas north of Rhinecliff. Eighteen sites were surveyed that were thought to have suitable habitat for *Hydrilla* over a two month period. Overall, no *Hydrilla* was found at any of the predetermined sites included in this survey, suggesting that there is a high probability that *Hydrilla* has not yet spread north of Newburgh. Common species observed were *Trapa natans, Vallisneria americana, Nuphar advena* and *Spirodela polyrhiza*.

Gene Expression Comparison between Wild and Restoration Populations of the Eastern Oyster

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The Eastern oyster, *Crassostrea virginica*, is a marine bivalve and a keystone species essential for the structure of the ecological community. The Eastern oyster filters plankton and other particles from the water they inhabit, and thus enhances water quality. The oyster population has suffered historical declines on the East coast, including around New York Harbor. Some of the most important causes of their decline have historically been overharvesting by humans, pollution, and introduced diseases in the marine environment. The purpose of our study is to use genetic techniques (RT-qPCR) to inform oyster restoration programs about how different oyster strains are responding to environmental conditions. We compare Maine hatchery oysters to wild oysters' genetic responses, by examining expression of functionally important genes. The goal is to determine whether gene expression differs between wild and 'restored' caged oysters, held under the same environmental conditions in the wild. To achieve this goal, we quantify gene expression of the heat shock protein 70, which is important for protecting cells against environmental stress; and beta actin, which is used as a control gene because its expression is not expected to be influenced by the environment. We observe the expression patterns among oysters grown in various locations around the New York Harbor, including Governors Island, Bush Terminal, and Soundview Park. This research will help determine whether restored oyster stock are phenotypically similar to wild oyster, or whether they represent functionally distinct populations.

Food web interactions and early detection of two aquatic invasive species, the bloody red shrimp, *Hemimysis anomala,* and the round goby, *Neogobius melanostomus*

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Predicting the impacts of invasive species on native food webs requires a combination of controlled feeding experiments and structured field surveys to determine spatial distribution and help with early detection in areas of potential expansion. The bloody red shrimp (BRS), *Hemimysis anomala*, and the round goby, *Neogobius melanostomus*, are both recent Ponto-Caspian aquatic invasive species that have expanded their range throughout the Great Lakes region into the Capital Mohawk and greater Hudson River regions of New York State. In this study, we investigate how the consumption rate of round goby and four other potential fish predators of BRS (alewife, lake trout, yellow perch and pumpkinseed sunfish) varies as a function of BRS density, light level, and substrate type. We also performed seine and plankton net surveys to determine the degree of spatial overlap between round goby and BRS at over 50 sampling locations along the Erie Canal and the Hudson River. The round goby predation experiments demonstrated no significant effects of substrate type on prey capture success, but increasing light levels were inversely related to consumption rate. Gobies ranked third in mean consumption rate (22 mysids hr-1) at the highest BRS density treatment compared to other fish predators (alewife > lake trout > round goby > yellow perch > pumpkinseed). Our survey results did not detect round goby further east than Rome, New York; however, BRS were found consistently throughout the Erie Canal and as far south as Poughkeepsie along the Hudson River.

Protecting Wetland Migration Pathways

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The New York – New Jersey Harbor & Estuary Program is starting a project to advance the protection of wetland migration pathways; places where tidal wetlands are likely and able to move with sea-level rise. With sea level rise, these vulnerable ecosystems encounter the “coastal squeeze,” where urban land uses do not allow for the migration of wetlands, an ecological process that had occurred for thousands of years prior to human existence. This understanding requires a change in restoration planning for wetlands. The question is not simply where the restoration opportunities are now; the questions are where are the restoration opportunities in the future and how do we protect those opportunities today?

This poster will introduce the concept of wetland migration pathways and the results of a parcel based analysis of pathways in coastal urban New Jersey. A similar analysis has previously been completed for the Hudson River wetlands by Scenic Hudson but no similar comprehensive effort exists for the New Jersey part of the Estuary. Results may include: acres of pathway per municipality, who owns them (public/private), current land uses in the pathways, relative contiguity of pathways to other natural areas, contaminated pathways, unprotected pathways (development threat), and other metrics of acquisition potential. While this analysis has not been completed, it is underway with data sets collected and methodologies presented to HEP's Restoration Work Group.

Resilience, Migration, and Long-Term Conservation of Hudson River Tidal Wetlands

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Rapid local Sea Level Rise (SLR) is impacting nearly 7,000 acres of freshwater and brackish tidal wetlands along the Hudson River estuary (HRE). We simulated wetland migrations and composition shifts under a range of possible future conditions using the Sea Level Affecting Marshes Model (SLAMM), adapting the model to reflect local SLR projections, and the unique freshwater tidal conditions and habitat types in the HRE. We used the results to prioritize sites for conserving wetland migration pathways, targeting currently undeveloped and unprotected uplands most likely to host future tidal wetlands and existing wetland complexes exhibiting high resilience under a range of possible future conditions. Results showed that appropriate conservation actions in the HRE can ensure that the projected wetland migration into upland areas will be sufficient to offset losses over the 21st century, and the system's resilience can be further enhanced by restoration and policy measures.

Changing Dynamics in Ramshorn-Livingston Marsh

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Preservation of the Hudson's tidal wetlands is fundamental to the health of the estuary. Through analyzing a 1-m sediment core from Ramshorn-Livingston Marsh, one of the largest and most well-preserved freshwater tidal marshes in New York State, we were able to reconstruct about 250 years of ecosystem response to human settlement. From 100-68 cm, large and heavy seeds are found in the core, possibly indicating a heavier flood regime capable of carrying these seeds. From 68 -20 cm, Asteraceae seeds and violets are present in the macrofossil profile and there is an increase in inorganic sediment from .12 g to .28 g per sample, both indicators of human settlement.

There is a sharp decrease in inorganic sediment from 0-20 cm depth in the core from a weight of 0.33 g to 0.05 g per sample and macrofossil analysis shows a switch from a diverse community of sedges to a monoculture of invasive cattail during the same period. Lead, copper, and calcium profiles obtained through x-ray fluorescence spectroscopy (XRF) all reflect human activity. Lead increases from 50 cm to 18 cm depth and subsequently decreases rapidly. XRF analysis also reflects a decrease in inorganic sediment, as aluminum, titanium, and silica all decrease in concentration from 20 cm to the top of the core. These findings reveal that an important freshwater tidal marsh which is thought to be healthy and intact is threatened by a loss of inorganic sediment which may be key to its resilience as sea level continues to rise.

Coupling virus and salinity transport through porous media

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Water contamination by viruses is becoming a serious outbreak in coastal urban areas. Several studies have demonstrated that the presence of viruses in beach sand and coastal water is a risk to human health.

Once microorganisms (viruses and bacteria) are in the surface water, they can be transported downstream with the flow as well as settle towards the bottom and potentially migrate within the sediments of the river bed. The fate and the transport of viruses in porous media is mainly governed by attachment and detachment processes at the solid-liquid interface. The salinity is one of the most important factors as it controls the electrostatic interactions between the microorganisms and the porous medium surface and, therefore, the speed of their migration. Salinity can be significant in estuarine river water, and it varies with daily tidal cycle. However, only few studies quantitatively analyze the effect of the salinity on the distribution of virus concentration in porous media.

Our study explores the effect of salinity on the instability of the virus front during transport in saturated porous media. A one dimensional transport model was developed following previous work. The model consists of two mass conservation equations of the virus and the salt concentration coupled through the constitutive equations of the attachment/detachment mechanism. Numerical and analytical models were developed to couple virus and salinity transport through the porous media. This work will help to gain an insight to understand the role of salinity on virus transport through porous media in coastal areas